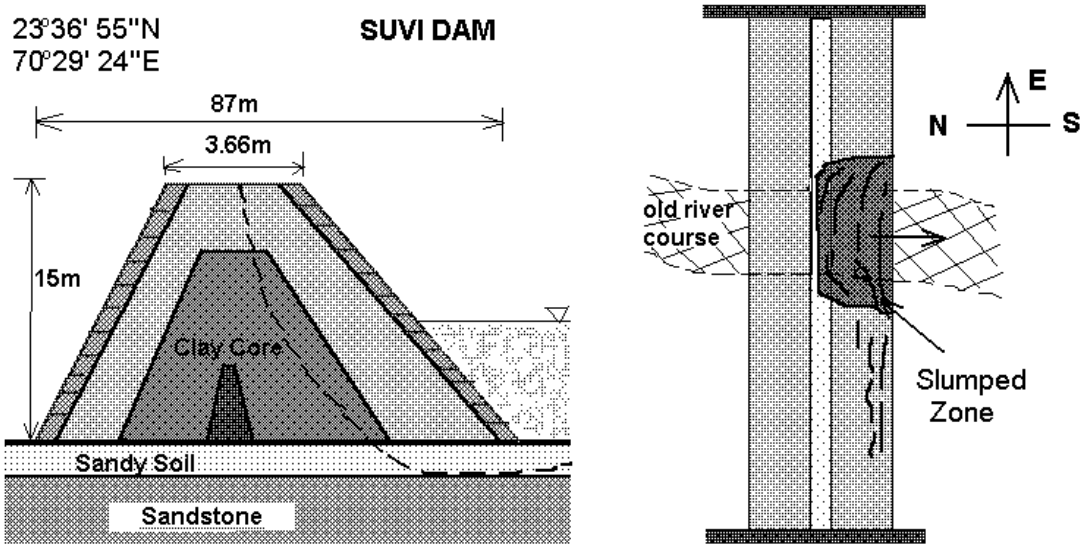
6 DAMS

Most of the dams are earth dams except a few which are stone masonary built. The dams are built for irrigational purposes. The list of major medium size dams is given in Table 6.1 There are more than 174 earth dams in the region. Figure 6.1 shows the location of dams. Seven medium sized dams and 14 small sized dams in Kutch were damaged. The major damaged dams are shown in the figure.

Figure 6.1 Locations of dams and major damaged dams

SUVI DAM: Suvi dam is built nearby Lilpar which is north of the presumed fault. The east-west length of the dam is about 2.7km. The crest of the dam is 3.66m wide and the bottom is 87m wide (Figure 6.2). The crest height is 15m. It is completed in 1666 for irrigation and water supply purposes. The position of the dam is 23^{o} 36’ 55”N;70^{o} 26’ 64”E. While the upstream side of the dam had multiple longitudinal cracks indicating to movement towards to the reservoir (Figure 6.3 and 6.4), no visible cracks were observed on the downstream side. The longitudinal direction of the dam was EW. The direction of the sliding took place towards the epicenter. Huge sliding occurred along a section, which was the old river course. It seems that the soil below may be liquefied. The foundation is sandstone and the surface deposit thickness should be about 1-2m. Some lateral spreading of ground was observed. Granular sands could be found along the cracks (Figure 6.4). This may be due to soil liquefaction as quartzitic sand with a repose angle of 32 degree are observed along the cracks. A large longitudinal crack appeared at the boulder toe of the dam. Boring and SPT were carried out to restore the damaged part before a rainy season (Figure 6.5).



(a) A skectch of dam cross-section (b) A sketch of the plan view

Figure 6.2 Damage to Suvi earth dam

Figure 6.3 Settlement and slumping of Suvi dam towards upstream side

Figure 6.4 Lateral spreading of the ground due to the liquefaction

Figure 6.5 Large crack at the boulder toe.

CHANG DAM: The Chang Dam with a height of 20m was built for irrigation purpose and it is an earth dam. The dam is mostly aligned in the EW direction with a curvature at its west end. The curved part of the dam failed (Figure 6.6). The downstream side of the dam moved northward while its upstream side moved southward. The failed part coincided with the old river stream. Although the base rock is mudstone with almost horizontal layering, the old river course may be consisted of sandy material. In the upstream side the sand boiling can be clearly observed even more than 50 days passed from the earthquake. A sketch of the dam failure is shown in Figure 6.7. It seems that the failure of the dam is due to liquefaction at its base as shown in Figure 6.8 and it resembles to the failure of San Fernandes dam. Furthermore, some lateral spreading could be observed at many locations around the reservoir. Water intake of this was masonry and it was totally collapsed (Figure 6.9).

Figure 6.6 Settlement and slumping of Chang dam

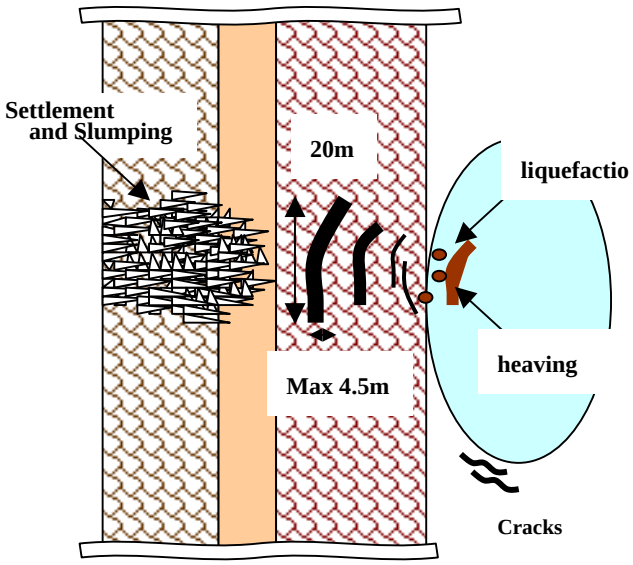


Figure 6.7 A sketch of failure of Chang earth dam

Figure 6.8 Upstream slope failure due to liquefaction

Figure 6.9 Failure of water intake tower

RUDRAMATA DAM: The dam was also earth-fill with a height of 20m. The downstream side of the dam was not damaged while the upstream side of the dam has cracks running along the longitudinal axis of the dam near the toe of the dam. The cracked section was removed and new soil placement was under construction. The water-intake tower is masonary and it was slightly damaged (Figures 6.10 & 6.11). In the dam reservoir some bulging of sandstone layers were visible. However, the cause of bulging was not well understood.

Figure 6.10 Rudramata dam

Table 6.1 Characteristics of Major dams in Kutch

Name	Type	River	Height	Slope	Year	Distance	Comment
Sanandhro	Masonary	Kali			1657		
Kankawati	Earthen	Kankawati			1656		
Nagmati	Masonary	Nagmati			1656		
Kaila	Earthen	Kaila			1616		
Rudramata	Earthen	Pur(Khari)				60	Damaged
Nirona	Earthen	Bhurud					
Gajansar	Earthen	Panjora					
Suvi	Earthen	Suvi	15	16	1666	30	Damaged
Nara	Earthen	Lakhpat			1681		
Fatehgarh	Earthen	Malan			1687	57	Damaged
Godhatad	Earthen	Lakhpat			1683		
Tapar	Earthen	Sakara	33			28	Damaged
Bhuki	Earthen	Bhuki					
Mathal	Earthen	Dhadodh					
Jangadia	Earthen	Khari					
Don	Earthen	Kharod					
Berachia	Earthen	Nayara					
Mitti	Earthen	Mitti					
Kaswati	Earthen	Kaswati			1676	45	Damaged
Kalaghoga	Earthen	Phoi			1687		
Chang	Earthen		20			15	Damaged
Nilpar	Earthen						Damaged
Shiviakha	Earthen					28	Damaged

Figure 6.11 Water intake tower of Rudramata dam

TAPPAR DAM:The 33m high Tappar dam blocks the flow of the rivers into Banni. The water from this dam go for the municipal and industrial use of Kutch's emerging industrial town of Gandhidham.

Big dams, namely Ranasagar, Jawaharsagar and Kota barrage, built on the Chambal river, in the Rajastan State (500km from the USGS epicenter) were not affected by the earthquake.

The main conclusions made during the inspection of dams are given below:

- Parallel longitudinal cracks were observed on the crest and upstream face of the dams which are apparently very deep and wide.
- The settlement of upstream face and crest of the dams was observed in most of the cases. In some dams, it was very large in gorge portion of the river and in few cases, a complete damage of earth dam in the gorge portion of river was observed. Such settlements are thought to be liquefaction of soil at the base of the dam.
- Transverse cracks were also found in most of the dams. These are mostly observed at the junction at spillway and earth dam.
- Cracks were seen in head regulator structure of many dams. In some dams, head regulator structure has completely collapsed.
- Water ponding was observed at downstream toe of some dams.
- Incidentally, all these dams were near empty due to the second successive year of drought so that the dam failures did not cause any problem at downstream side.
- Several dams such as Chang and Suvie were sustained severe damage, so that the rapid restoration is needed before the rainy season.